Immingham Green Energy Terminal

Environmental Impact Assessment

Preliminary Environmental Information Report

Volume II – Main Report

Chapter 16: Physical Processes

Associated British Ports

Document History

Document Ref	60673509_EIA_PEI REPORT		
Revision	P 1.0		
Author	Alan Lewis		
Signed		Date	20/12/2022
Approved By	Richard Lowe		
Signed		Date	20/12/2022
Document Owner	AECOM		

Table of contents

Chapter Pages

Tables

16 Physical Processes

16.1 Introduction

16.1.1 This chapter presents the preliminary findings of the assessment of the potential effects of the Project on Physical Processes. For more details about the Project, including construction methodology, layout and life span, refer to **Chapter 2: The Project** of this PEI Report.

16.1.2 This stage identifies the potential environmental changes that result from the proposed activity and the processes that are likely to be affected. These are together referred to as the impact pathways, which have the potential to affect identified receptors (within this and other topic chapters). The following impact pathways have been considered as part of the assessment:

a. Hydrodynamics;

b. Sediment transport;

c. Plume dispersion; and

d. Waves.

16.1.3 Where predicted impacts to these pathways have the potential to subsequently impact specific features of interest (such as the local coastline, nearshore sandbank and channel system, existing berth and jetty infrastructure), these have been identified and considered within the assessment in **Section 16.8**.

16.1.4 There may be interrelationships related to the potential effects on Physical Processes and other disciplines. Therefore, also refer to the following chapters:

a. **Chapter 9: Nature Conservation (Marine Ecology)**;

b. **Chapter 10: Ornithology**;

c. **Chapter 15: Historic Environment (Marine)**;

d. **Chapter 17: Marine Water and Sediment Quality**;

e. **Chapter 18: Water Quality, Coastal Protection, Flood Risk and Drainage**; and

f. **Chapter 19: Climate Change**.

16.1.5 This chapter is also supported by the following figures (PEI Report, Volume III):

a. **Figure 16.1**: Regional setting within wider Humber;

b. **Figure 16.2**: Bathymetric data across Project site;

c. **Figure 16.3:** Particle Size Distribution (PSD) across Project site and disposal grounds;

d. **Figure 16.4**: Project scheme elements;

e. **Figure 16.5**: Maximum excess SSC from peak flood (top) and peak ebb (bottom) disposal at HU060;

f. **Figure 16.6**: Maximum SSC and sedimentation from dredge and disposal across full modelled period;

g. **Figure 16.7**: Timeseries of excess SSC (top) and sedimentation (bottom) at locations down- (left) and up-estuary (right);

h. **Figure 16.8**: Instantaneous excess SSC (top) and sedimentation (bottom) following discrete disposal events;

i. **Figure 16.9**: Peak baseline flows (top) and impact of scheme (bottom) for flood tide (left) and ebb tide (right);

j. **Figure 16.10**: Timeseries of changes to flows and bed shear stress for sites P1, P2, P3 and P4;

k. **Figure 16.11**: Timeseries of changes to flows and bed shear stress for sites P5, P7, P8 and P9;

l. **Figure 16.12**: Timeseries of changes to flows and bed shear stress for sites P6, P10, P11 and P12;

m. **Figure 16.13**: Modelled difference to baseline bed level change over a mean spring neap cycle; and

n. **Figure 16.14**: Modelled change in Hs for 0.5-yr wave event (left) and 50-yr wave event (right) from NE (top), E (middle) and SE (bottom).

16.1.6 A numerical model calibration report (covering each of the different modules) is provided in **Appendix 16.A** (PEI Report, Volume IV).

16.1.7 Numerical modelling tools and conceptual analyses have been used to predict coastal processes and hydrodynamic effects by comparing the baseline and future environmental conditions created by the Project. This includes predicting the changes to tidal water levels, currents, and waves. It also includes modelling of sediment transport pathways (including assessment of potential changes to erosion and accretion patterns) and the fate of sediment plumes from marine construction and maintenance dredging and disposal activities.

16.1.8 Changes in hydrodynamic (and sedimentary) processes are considered in the context of climate change (specifically sea level rise) over the engineering design period of the Project by assessing the effects under projected future sea levels. As further sampling data are acquired this information will be analysed to optimise the construction and dredging methods and minimise changes in physical processes during construction and operation. Some existing ground investigation data does exist, which has been used to inform the sediment transport and dredge plume modelling. Additionally, this data will be used to inform the specifications of the project specific ground investigation (GI) works.

16.1.9 Preliminary modelling has been completed using existing models of the Humber Estuary, with updates to ensure mesh resolution and model performance across the primary study area remains suitable. The modelling utilises the state of the art Mike suite of modelling software from the Danish Hydraulics Institute (DHI). These modelling tools have previously been developed specifically for oceanographic, coastal and estuarine applications within the Humber region. The selected modelling tools have been updated with the latest available bathymetric and topographic data and have undergone a further verification stage using local measurements collected for the Project (see **Appendix 16.A** (PEI Report, Volume IV)).

16.1.10 Following the refinement of the models to replicate the baseline conditions, the models have then been updated to include a representation of the marine elements of the Project, namely the jetty, the dredge footprint and the dredge disposal site(s). The models also include a representation of any other coastal and marine developments that may overlap or interact with the Project to allow the potential for cumulative effects to be assessed.

16.1.11 There is sufficient available information and data sources to support the numerical modelling and conceptual analyses and no further field survey work is considered necessary. Where relevant, additional information from planned surveys will be used to validate model results, e.g. sediment sampling carried out in line with OSPAR[1] requirements.

16.2 Approach to Assessment

Scope and Methods

16.2.1 A scoping exercise was undertaken in August 2022 to establish the form and nature of the Physical Processes assessment, and the approach and methods to be followed.

16.2.2 The Scoping Report (**Appendix 1.A** (PEI Report, Volume IV)) records the findings of the scoping exercise and details the technical guidance, standards, best practice and criteria being applied in the assessment to identify and evaluate the likely significant effects of the Project on Physical Processes.

16.2.3 Following receipt of the Scoping Opinion (**Appendix 1.B** (PEI Report, Volume IV)) as to the information to be provided in the Environmental Statement (ES), the requirements set out in **Table 16.1** have been identified by the Planning Inspectorate as those to be taken account of as part of the ongoing physical processes assessment.

[1] 'OSPAR' relates to the Convention for the Protection of the Marine Environment of the North-East Atlantic.

Table 16.1: Scoping Opinion Comments on Physical Processes

Consultee	Summary of Response	How comments have been addressed in this chapter
Planning Inspectorate	The Scoping Report refers to physical environmental receptors "such as the local coastline and the nearshore sandbank and channel system, along with existing berth and jetty infrastructure". The ES must clearly describe the receptors to be considered in the assessment and explain how/why they were identified. The ES should consider whether the changes to physical processes would impact on sea defences through changes to wave patterns or sedimentation, and the likelihood of impacts on any telemetry devices in the area of Immingham docks.	Receptor pathways have been identified as, sediment transport, plume dispersion and waves. For each of these receptor pathways, the potential impacts on the local coastline (including existing defences), nearshore sandbank and channel system, existing berth and jetty infrastructure have been assessed in **Section 16.5**.
	The Scoping Report states that for impacts on physical receptors (i.e. local coastline, sandbank and channel system, existing infrastructure) an assessment of effect significance would be undertaken following the methodology presented in section 4.6 of Chapter 4 The EIA Process. The ES should explain and justify how the evaluation of the importance/ value and sensitivity of relevant physical processes receptors has been undertaken, and how the magnitude of impact has been defined for this aspect.	The approach to the assessment for physical processes is outlined in **Section 16.2**. Where applicable, the assessment for physical processes receptors is carried out in line with the EIA methodology in **Chapter 5: EIA Approach**.
	Item J mentions relevant local policy and we would highlight the need to consider the relevant Shoreline Management Plan and Humber Estuary schemes/plans in relation to this topic.	Reference is made to local planning policy and plans including the River Basin Management Plan and Shoreline Management Plan and information has been provided as to the relevance of these plans to the Project in relation to physical processes (**Table 16.2** in **Section 16.2**).
Environment Agency	This Chapter sets out what will be done to assess the changes to physical processes and what these impacts will be. We are pleased that at this stage no issues have been scoped out. However, we would like the assessment to also specifically	Preliminary modelling of wave patterns and sediment transport has been carried out and the assessment is presented in **Section 16.5**.

Consultee	Summary of Response	How comments have been addressed in this chapter
	consider whether the changes to physical processes would have an impact on sea defences through changes to wave patterns or sedimentation. Paragraph 15.4.8 states that the jetty will not be decommissioned and is likely to remain part of the port estate. An engineering standard of 50 years has been given for the development. If the jetty is to remain in place longer than 50 years, the assessments need to reflect this in an appropriate design life for the marine element of the proposed development. Paragraph 15.6.9 summarises the relevant legislation, policy and technical guidance, which will be cross-referenced as appropriate. Item J mentions relevant local policy and we would highlight the need to consider the relevant Shoreline Management Plan and Humber Estuary schemes/plans in relation to this topic.	The Shoreline Management Plan and other plans relevant to the Humber Estuary have been considered and are detailed in **Table 16.2**.

16.3 Assessment Method

16.3.1 The methods adopted for the assessment of the physical processes changes differs slightly to those adopted for other environmental topics. This is because whilst the Project has the potential to cause changes to hydrodynamic and sedimentary processes, these changes are not, in themselves, generally recognised as environmental features/ receptors and, therefore, do not equate to 'effects'. The effects would instead be the consequence of these changes on other environmental features. For example, 'changes' in the transport and deposition of sediment may 'effect' the structure and function of marine habitats and their associated species.

16.3.2 The physical processes assessment applies the same impact assessment methodology as described in **Chapter 5: EIA Approach** and assesses the potential 'exposure to change' resulting from the impact pathways that have been scoped into the assessment. The consequent significance of effects resulting from physical processes changes on other environmental features/ receptors would be assessed in other topic-specific ES chapters, including **Chapter 9: Nature Conservation (Marine Ecology)**; **Chapter 10: Ornithology**; **Chapter 15: Historic Environment (Marine)**; **Chapter 17: Marine Water and Sediment Quality**; and **Chapter 18: Water Quality, Coastal Protection, Flood Risk and Drainage**.

16.3.3 It is recognised, however, that physical processes changes may potentially impact on physical environmental receptors, such as the local coastline and the nearshore sandbank and channel system, along with existing berth and jetty infrastructure. For these physical receptors, therefore, an assessment of effect significance is undertaken following the methodology presented in **Chapter 5: EIA Approach**. In accordance with published guidance and an established approach that has been used in numerous previous EIAs, the assessment includes an evaluation of the importance/ value and sensitivity of relevant physical processes receptors.

16.4 Legislation, Policy and Guidance

16.4.1 **Table 16.2** presents the legislation, policy and guidance relevant to physical processes assessment and details how their requirements will be met.

Table 16.2: Relevant legislation, policy and guidance regarding Physical Processes

Legislation / Policy / Guidance	Consideration within the PEI Report
The Marine and Coastal Access Act 2009 (MCAA) (Ref 16-2)	
The MCAA provides the legal mechanism to help ensure clean, healthy, safe, productive, and biologically diverse oceans and seas by putting in place a new system for improved management and protection of the marine and coastal environment. The MCAA established the Marine Management Organisation (MMO)	Information relevant to the marine licensing process is provided in the PEI Report including characterisation of the physical processes baseline (**Section 16.3**) and a preliminary assessment of the exposure to change and potential impacts (**Section 16.5**).

Legislation / Policy / Guidance	Consideration within the PEI Report
as the organisation responsible for marine planning and licensing. The Project will require a Marine Licence for the elements of the works below Mean High Water Springs including dredging, disposal and placing or removing objects on or from the seabed. For NSIPs the Development Consent Order (DCO) where granted may include provision deeming a marine licence to have been issued under Part 4 of the Marine and Coastal Access Act 2009. The MMO is responsible for enforcing, post-consent monitoring, varying, suspending, and revoking any deemed marine licence(s) as part of the DCO.	
The Planning Act 2008 (PA2008) (Ref 16-3)	
Whilst the MCAA regulates marine licensing for works at sea, section 149A of the Planning Act 2008 enables an applicant for a DCO to include within the Order a Marine Licence which is deemed to be granted under the provisions of the MCAA.	Information relevant to the marine licensing process is provided in the PEI Report including characterisation of the physical processes baseline (**Section 16.3**) and a preliminary assessment of the exposure to change and potential impacts (**Section 16.5**).
The Water Environment (WFD) (England and Wales) Regulations 2017 (Ref 16-4)	
The Water Framework Directive (2000/60/EEC) is transposed into UK law through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 as amended, known as the Water Framework Regulations[2]. In terms of water and sediment quality, *"Good ecological status/potential"* has regard to physico-chemical quality elements, and specific pollutants. The Good ecological status/potential assessment also considers biological and hydromorphological elements. "Good chemical status" has regard to a series of priority substances and priority hazardous substances.	The WFD surface water bodies are described in **Chapter 17: Marine Water and Sediment Quality**. A WFD Compliance Assessment will be prepared to support the DCO application. This includes consideration of the potential risks for several key receptors, including hydromorphology. The WFD Compliance Assessment will be informed by the outcomes of the physical processes assessment reported within this chapter.
The Conservation of Habitats and Species Regulations 2017 (Ref 16-5)	
The Habitats Directive and Birds Directive are transposed into UK law through the Conservation of Habitats and Species	**Section 16.3** characterises the baseline for physical processes. A preliminary assessment of the exposure to change and potential impacts is described in

2 Following the UK leaving the EU, the main provisions of the WFD have been retained in English law through The Floods and Water (Amendment etc.) (EU Exit) Regulations 2019.

Legislation / Policy / Guidance	Consideration within the PEI Report
Regulations 2017 as amended, known as the "Habitats Regulations"[3]. The Habitats Regulations provide for the designation and protection of 'European sites', the protection of 'European protected species' and the adaptation of planning and other controls for the protection of European Sites. The Regulations also require the compilation and maintenance of a register of European sites, to include SACs (classified under the Habitats Directive) and SPAs (classified under the Birds Directive). These sites form the Natura 2000 network. These regulations also apply to Ramsar sites (designated under the 1971 Ramsar Convention for their internationally important wetlands), candidate SACs (cSAC), potential Special Protection Areas (pSPA), and proposed and existing European offshore marine sites.	**Section 16.5** which has informed the preliminary assessment of impacts on protected habitats and species presented in **Chapter 9: Nature Conservation (Marine Ecology)** and **Chapter 10: Ornithology**. In particular information is provided with respect to the following potential impact pathways: • Physical damage through disturbance and/or smothering of supporting habitats and associated prey resources for interest features. • Physical damage through alterations in physical processes of supporting habitat for interest features. • Non-toxic contamination through elevated SSC resulting in effects on interest features, or their prey resources. A Habitats Regulations Screening report has been produced and is provided in **Appendix 9.C** (PEI Report, Volume IV). This report will inform the consultation process and will aid the Competent Authorities[4] in determining whether the Project has the potential for a likely significant effect (LSE) on the interest features and/or supporting habitat of a European/Ramsar site either alone or in-combination with other plans, projects and activities and, if so, will inform the requirement to undertake an Appropriate Assessment (AA) of the implications of the proposals in light of the site's conservation objectives.
The Waste (England and Wales) Regulations 2011 (as amended) (Ref 16-8)	
The Regulations set out the measures required for the prevention of, production and management of waste. This describes the purpose of a waste prevention program with waste prevention measures and makes reference to monitoring by appropriate authorities using qualitative or quantitative benchmarks. It also outlines the waste hierarchy which ranks waste management options according to what is best for the environment. It gives top priority to preventing waste in the first place. When waste is created, it gives priority to preparing it for re-use, then	**Section 16.3** provides baseline information on sediment characteristics. This information will inform a Waste Hierarchy Assessment (WHA) for the Project which would be undertaken to determine the Best Practical Environmental Option (BPEO) for dealing with the dredge arisings (see **Chapter 5: EIA Approach**. The WHA would be informed by the outcomes of this physical processes assessment. The option of disposal in the estuary will be assessed as part of this physical processes assessment and is described in **Section 16.5**.

3 Following the UK leaving the EU, the Conservation of Habitats and Species Regulations 2017 have been modified by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019.

4 The MMO and North East Lincolnshire are Competent Authorities for the HRA. However it is noted that ABP is also a Competent Authority under the UK Habitats Regulations.

Legislation / Policy / Guidance	Consideration within the PEI Report
recycling, then recovery, and last of all disposal (e.g. landfill). For any dredging project, the *in situ* characteristics of the material (physical and chemical), the method and frequency of dredging (and any subsequent processing), determines its characteristics in the context of securing a consent that is in compliance with the waste hierarchy. This understanding is central to the consideration of management options for dealing with dredged material in light of the requirements of the Regulations. Where prevention of the dredging is not possible, then the volume to be dredged should be minimised, and options for the re-use of the material, recycling and other methods of recovery must be considered in the first instance. In the context of re-use and recycling of dredge material this could include engineering uses, agricultural and product uses, environmental enhancement or post treatment of the dredge material to change its character with a view to determining a potential use. Should no practical and cost-effective solutions be identified, only then can options for the disposal of the dredged material be considered. These include marine disposal in licensed deposit sites or land-based disposal in terrestrial landfill.	
National Planning Policy Statement for Ports (NPSfP) (Ref 16-9)	
The NPSfP provides the policy framework for nationally significant infrastructure projects involving new port development (DfT, 2012). In order to meet the requirements of the Government's policies on sustainable development, the NPSfP requires that new port infrastructure should also, amongst other things, assess the impact on coastal processes, be adapted and resilient to the impacts of climate change and provide high standards of protection for the natural environment. It also advises in Paragraph 5.3.5 that applicants should assess the impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development has an impact on coastal processes, the applicant must demonstrate	A physical processes chapter has been prepared for the PEI Report. A preliminary assessment of the exposure to change and potential impacts on physical processes is described in **Section 16.5**.

Legislation / Policy / Guidance	Consideration within the PEI Report
how the impacts will be managed to minimise adverse impacts on other parts of the coast. Paragraph 5.3.5 of the NPSfP advices that applicants also to assess the vulnerability of the proposed development to coastal change in the context of climate change during the project's operational life and any decommissioning period. Paragraph 5.3.8 states that the decision-maker should be satisfied that the proposed development will be resilient to coastal change, taking account of climate change, during the project's operational life and any de-commissioning period.	
UK Marine Policy Statement (MPS) (Ref 16-10)	
The MPS is the framework for preparing marine plans and taking decisions affecting the marine environment. The MPS also sets out the general environmental, social, and economic considerations that need to be taken into account in marine planning and provides guidance on the pressures and impacts that decision makers need to consider when planning for and consenting development in the UK marine areas. Section 2.6.8 of the MPS is relevant to the Physical Processes assessment. In particular, paragraph 2.6.8.4 states, amongst other things, that - *"Marine plan authorities should be satisfied that activities and developments will themselves be resilient to risks of coastal change and flooding and will not have an unacceptable impact on coastal change..."*. In addition, paragraph 2.6.8.6 notes that the impacts of climate change throughout the operational life of a development should be taken into account in assessments, and that any geomorphological changes that an activity or development has on coastal processes, including sediment movement, should be minimised and mitigated.	A physical processes chapter has been prepared for the PEI Report. A preliminary assessment of the exposure to change and potential impacts on physical processes is described in **Section 16.5**. Where relevant mitigation has been considered in **Section 16.4**.
UK Marine Strategy (Ref 16-11)	
The aim of the UK Marine Strategy is to protect the UK's marine environment. The Strategy sets out a comprehensive framework for assessing, monitoring, and taking action to achieve the UK's shared vision for clean,	The anticipated pressures exerted on the marine environment by the Project are considered to be of sufficiently small magnitude, in the context of UK Marine Regions, that they are unlikely to be a significant issue. The Strategy is, therefore, not

Legislation / Policy / Guidance	Consideration within the PEI Report
healthy, safe, productive, and biologically diverse seas. It aims to achieve good environmental status of marine waters by 2020 (followed by a six-year review) and then to protect the resource base upon which marine-related economic and social activities depend. The Strategy constitutes a vital environmental component of future maritime policy, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment. The UK Marine Strategy applies to the landward boundary of coastal waters as defined under the WFD (i.e., from mean high water springs (MHWS)) to the outer limit of the UK Exclusive Economic Zone (EEZ), as well as the area of UK continental shelf beyond the EEZ. Government reporting against the Strategy is a cyclical process, and the most recent assessments and Marine Strategy documents were updated in 2019.	considered further in this PEI Report with regards to the physical processes assessment.
East Inshore and East Offshore Marine Plans (Ref 16-12)	
The first Marine Plans include the East Inshore and East Offshore Marine Plans, which are collectively referred to as 'the East Marine Plans'. These were formally adopted on 2 April 2014 (Defra, 2014). There are no policies within the East Marine Plans related specifically to coastal processes. Policy CC1, however, states that: *"Proposals should take account of:* • *how they may be impacted upon by, and respond to, climate change over their lifetime; and* • *how they may impact upon any climate change adaptation measures elsewhere during their lifetime. Where detrimental impacts on climate change adaptation measures are identified, evidence should be provided as to how the proposal will reduce such impacts."*	With respect to this physical processes assessment, the future baseline is discussed in **Section 16.3**, to provide context to the predicted changes (as a result of the Project) which are described in **Section 16.5**.
Flamborough Head to Gibraltar Point Shoreline Management Plan (SMP) (Ref 16-13)	
The Flamborough Head to Gibraltar Point SMP identifies the most sustainable approach for managing the risk from coastal flooding and erosion over the short, medium and long-term.	The PEI Report recognises that the Project lies adjacent to Policy Unit L 'East Immingham to Cleethorpes' where the policy in the short, medium and long term is 'Hold the Line' will influence current and future baseline conditions (**Section 16.3**).

Legislation / Policy / Guidance	Consideration within the PEI Report
IT covers the Humber Estuary coastline up to Immingham.	
North East Lincolnshire Local Plan 2013 to 2032 (Ref 16-14)	
The North East Lincolnshire Local Plan was adopted in 2018 and covers the period 2013 to 2032. Within its Spatial Portrait, the Local Plan highlights the importance of the 'Estuary Zone' of the local authority area, which includes the 'nationally important port' of Immingham. When considering the detail of how the economy of the area will be developed, the Plan specifically identifies at the outset that there are good expectations of growth within the ports and logistics sector. On the policies map which accompanies the Local Plan, the site of the Project is shown as being located within an area identified as 'Employment – Operational Port'. In addition, Policy 34 of the plan makes clear that: *"Water management* *1. Development proposals that have the potential to impact on surface and ground water should consider the objectives and programme of measures set out in the Humber River Basin Management Plan."* The Humber River Basin Management Plan provides a framework for protecting and enhancing the benefits provided by the water environment within the Humber River Basin District and informs decisions on land-use planning. The Humber River Basin District covers an area of 26,100 km² and extends from the West Midlands in the south, northwards to North Yorkshire and from Staffordshire in the west to part of Lincolnshire and the Humber Estuary in the east	The Project is located largely within the administrative area of North East Lincolnshire, although elements of the marine infrastructure fall beyond the local Council's administrative boundary. A preliminary consideration of impacts on physical processes is provided in **Section 16.5**. This will also be assessed in the WFD Compliance Assessment which will be submitted with the DCO application and will consider WFD objectives as outlined in the Humber River Basin Management Plan.
PINS Advice Note Eighteen: The Water Framework Directive (Ref 16-15)	
Advice Note Eighteen (Planning Inspectorate, 2017) explains the information that the Inspectorate considers an applicant must provide with their Nationally Significant Infrastructure Project (NSIP) application in order to clearly demonstrate that the WFD and the Water Environment (WFD) (England and	The WFD Compliance Assessment for the Project will contain the information specified in this guidance as appropriate. The WFD Compliance Assessment will be informed by the outcomes of the physical processes assessment in **Section 16.5**.

Legislation / Policy / Guidance	Consideration within the PEI Report
Wales) Regulations 2017 have been appropriately considered. The Advice Note also refers to Environment Agency guidance (as described above) in terms of the WFD process and the information required. Furthermore, the guidance describes the relevant bodies to be consulted in the pre-application process, and the presentation of information.	

Stakeholder Engagement

16.4.2 A range of stakeholders have been engaged as part of the scoping process to obtain their views on the Project and the scope of the Physical Processes assessment, the results of which are presented within the Scoping Opinion (**Appendix 1.B** of PEI Report, Volume IV).

Limitations and Assumptions

16.4.3 The information presented in this preliminary assessment reflects that obtained and evaluated at the time of reporting and is based on an emerging design for the Project and the maximum likely extent of land required for its construction and operation.

16.4.4 The findings of this preliminary assessment may be subject to change as the design of the Project is developed and refined further through the assessment and consultation processes, and as further research and investigative surveys are completed to fully understand its potential effects.

16.4.5 This preliminary assessment has been undertaken based on the following assumptions:

a. The Project is implemented as described in **Chapter 2: The Project** (with regards berth pocket location, depths, jetty and pontoon pile locations and dimensions).

b. Numerical modelling is based on a scenario with all elements of infrastructure in place including up to two berths and is considered a 'worst-case' scenario.

c. The dredging requirements for the Project will involve the use of a backhoe dredger (e.g. Mannu Pekka or similar) and potentially trailing suction hopper dredger (TSHD) (e.g. Cork Sand and Long Sand or similar). The backhoe dredging will involve the excavated material being loaded directly to attendant barges for disposal. Dredge operations will be continuous and operate 24 hours a days and seven days a week until the full dredge volume has been removed.

d. There will be subsequent transit of material and disposal at existing licensed disposal sites HU056 and HU060 (as described in **Section 16.5**). Where necessary, any inerodible boulder/glacial clay would be disposed of at site

HU056, whilst HU060 is to be used to dispose of any sand/silt (alluvium) material.

e. Following construction of the Project, vessels operating from the newly constructed berth(s) are assumed with dimensions described in **Chapter 2: The Project**.

f. That barge access to the disposal sites can be achieved throughout the full tidal cycle (this is considered to be a conservative, worst-case assumption for dredging and disposal operations and the subsequent plume development).

g. The dredge volumes assumed are a total of approximately 100,000 m^3. This value (including a split across material type) will be confirmed by sediment sampling carried out in line with OSPAR requirements.

16.4.6 Whilst these are assumptions, the preliminary assessment within this PEI Report has been undertaken considering the anticipated worst-case scenario in respect of physical processes receptors across the wider study area, including at the dredge, piling and disposal locations. Specific assumptions (and associated methodology) for each assessment are detailed in the relative sections of **Section 16.8**.

16.5 Study Area

16.5.1 The study area for this assessment is the area over which potential direct and indirect effects of the Project are predicted to occur during the construction and operational periods.

16.5.2 The direct effects on physical processes are those confined to the areas within the footprint of the Project, i.e., the piers, pontoons, dredged berth pocket and disposal of dredge material at the proposed disposal sites.

16.5.3 Indirect effects are those that may arise due to wider changes in the estuary flow and sedimentary regime and any associated change to the estuary morphology as a result of the Project.

16.5.4 As a consequence, the study area for the physical processes topic comprises the Project site and the adjacent Immingham coastline, the existing jetties across the near-field and the central part of the Humber Estuary, the area generally between Sunk Dredged Channel (SDC) and Halton Middle and the proposed spoil grounds HU056 and HU060. Within the far-field region, the study area includes the wider Humber Estuary from the mouth to up-estuary of the Hull Bend (see **Figure 16.1** (PEI Report, Volume III) for locations).

16.6 Baseline Conditions

Existing Baseline

16.6.1 The description of the existing baseline draws on available information from new and existing surveys, reports, dredging records and publicly available data. Additional, project-specific surveys are currently underway, and the results will be used to update the baseline characterisation within the ES.

Bathymetry and morphology

16.6.2 In plan shape, the Humber Estuary has a meandering funnel shape widening towards the mouth, where a southerly orientated spit has formed in response to littoral drift processes and antecedent geological controls. The funnel shape is demonstrated by the exponential decrease in estuary area, width, and depth from the mouth to the head.

16.6.3 The estuary can be divided into three regions (see **Figure 16.1** (PEI Report, Volume III) for locations):

a. The Inner Humber (Trent Falls to Humber Bridge).

b. The Middle Humber (Humber Bridge to Grimsby).

c. The Outer Humber (Grimsby to Spurn Point).

16.6.4 In the Inner Humber, downstream of Trent Falls, where the River Trent and River Ouse merge, the estuary is characterised by a number of extensive intertidal banks composed of sand/silt. These banks include Winteringham Middle Sand, Redcliff Middle Sand, Hessle Sand and Barton Ness Sand.

16.6.5 The Middle Humber, where the Project is located, is similar in its characteristics to the Inner Humber, having a number of banks and channels which have a preferred configuration. In the northernmost section, the main channel lies close to the Hull Waterfront, but westwards, where it meets Hessle Sand, a secondary channel develops along the southern shore. Down-estuary this reach is dominated by Skitter and Foul Holme Sands.

16.6.6 The Outer Humber is dominated by a three-channel system at the mouth (offshore of Spurn Head), a large, submerged sandbank (the Middle Shoal, located approximately in the middle of the estuary offshore of Grimsby), and a single deep channel leading to the Middle Humber. The three channels are Haile Channel (to the south of the mouth of the Humber), Hawke Channel (to the northern side of the mouth, located off the tip of Spurn Head) and Bull Channel (in between the two). Up-estuary, Hawke Channel is extensively dredged and the resulting channel, known as Sunk Dredged Channel (SDC), provides shipping access to the ports of Immingham and Hull. The presence of boulder clay deposits in the Outer Humber provides a geological constraint that influences the position of some of the sand banks, intertidal areas and Spurn Point itself. The Outer Humber contains a number of disposal grounds.

16.6.7 The Humber Estuary has a macro tidal range, fast flows and a high background suspended sediment content. This means the bed of the estuary is very dynamic in its morphology, both in the short term and on longer time scales, particularly in areas where there are no constraints, either geological or man-made. This dynamism manifests itself in cyclical variations in the positions of channels and banks throughout different regions of the estuary, with many of these regions showing an interconnectivity of process. The dominant influences on morphological change are tides, waves and freshwater flows, tidal surges and biological activity.

16.6.8 These influences produce changes in SSC, deposition rates, bed composition and ultimately channel/bank configurations. The dynamic nature of the Humber is illustrated by the interactions existing between the various bank systems in the Inner and Middle Humber. Channel migration in the Inner Humber releases sand, which forms banks off Barton and New Holland in the Upper Middle Humber. Furthermore, there is a sediment exchange between Barton Ness Sand and Skitter Sand lower down the Humber, which ultimately helps determine the shape and levels across Halton Flats. This variability in the banks and channels has been particularly noticeable around the Hull Bend during the last circa 20 to 25 years, with large changes to the intertidal banks and secondary channels in the areas of Hull Middle, Skitter Sand and Halton Flats.

16.6.9 Further down-estuary, between Immingham and Grimsby, the estuary is at its deepest, and relatively speaking, this is its most stable location. The main channel varies between 10m and 20m below Chart Datum (CD) and is bounded by steep 'hard sides' thought to comprise boulder clay, which are relatively in-erodible to present-day hydrodynamics. On the south side of the channel a relatively wide and gently sloping shallow subtidal 'ledge' exists, predominantly associated with the construction of the Grimsby Dock System. To the north, near Hawkins Point, the intertidal area is narrow compared to the areas up and down the estuary. This is due to human intervention through the reclamation of Sunk Island in this area.

16.6.10 Across the Project, the near field bathymetry is influenced by the deeper approaches to the Port of Immingham and the relatively shallower subtidal region behind the existing jetties (**Figure 16.2** in PEI Report, Volume III). Bed elevation within the approaches to Immingham, the SDC and on the berths at IOT varies in the approximate range of -8m to -20 mCD. Across the Project site, bed levels range from around -16 mCD offshore, sloping up towards the land along the Immingham foreshore. The intertidal area adjacent to the Project is around 100 m in width, narrowing slightly to the south, to around 80 m south of the landward end of the jetty(s).

16.6.11 A review of historical bathymetric charts extending both up and down estuary of the Project shows that in the 1930s, the channel up estuary was considerably deeper than present day, with depths of the order of -16 mCD centred about 1km from the shoreline. The channel has consistently in-filled until about 1990, resulting in a depth of around -7 mCD. During the last 15 years, depths have been relatively stable, although variations between -6m and -7mCD have occurred in Whitebooth Road (**Figure 16.1** in PEI Report, Volume III). Around the Project site (including Stallingborough Flats and the wider Immingham frontage), bed levels have remained relatively stable over time.

Tides and water levels

16.6.12 The Humber Estuary is macro tidal with a mean spring tidal range of 5.7m at Spurn increasing to 7.4m at Saltend then decreasing to 6.9 m at Hessle, which is 45km inland. Tides are semi diurnal with a slight diurnal inequality (one slightly higher high water followed by a slightly lower one), amounting to a 0.2 m difference in high water spring tides at Immingham. Standard tidal levels at Immingham are provided in **Table 16.3**.

Table 16.3: Standard tide levels for Immingham

Tidal Level		Immingham	
		mCD	mODN
Highest Astronomical Tide	HAT	8.00	4.10
Mean High Water Springs	MHWS	7.30	3.40
Mean High Water Neaps	MHWN	5.80	1.90
Mean Sea Level	MSL	4.18	0.28
Mean Low Water Neaps	MLWN	2.60	-1.30
Mean Low Water Springs	MLWS	0.90	-3.00
Lowest Astronomical Tide	LAT	0.10	-3.80
Mean Spring Tidal Range	(MHWS – MLWS)	6.40 m	
Mean Neap Tidal Range	(MHWN – MLWN)	3.20 m	
Note: Conversion from mCD to mODN at Immingham = -3.90 m.			

Source: UKHO 2022 (Ref 16-16)

16.6.13 The Humber tides are driven by the amphidromic system centred off the west coast of Denmark in the central North Sea. As the tide passes south of North Shields, it enters shallow water conditions which amplify the tidal range. This amplified tidal range drives the Humber tidal system so that the macro tidal range within the estuary is a product of the general morphology of the east coast as well as of the estuary itself.

Extreme water levels

16.6.14 Current extreme predictions determined by the Environment Agency for Immingham are the most up-to-date and appropriate for this review (Ref 16-17). These are provided in **Table 16.4** for a baseline year of 2017.

Table 16.4: Predicted extreme water levels for the Port of Immingham (Ref 16-17)

Return Period (Years)	Annual Exceedance Probability (%)	Extreme Water Level (mODN)
1	100	4.15
2	50	4.25
5	20	4.40
10	10	4.51

Return Period (Years)	Annual Exceedance Probability (%)	Extreme Water Level (mODN)
20	5	4.62
25	4	4.66
50	2	4.77
75	1.3	4.85
100	1	4.90
150	0.67	4.97
200	0.5	5.03
250	0.4	5.06
300	0.33	5.10
500	0.2	5.20
1,000	0.1	5.34
10,000	0.01	5.85

16.6.15 The maximum water level currently recorded at Immingham occurred on 5 December 2013 at 19:00 hours with a level of 5.22m Ordnance Datum Newlyn (ODN) compared to the predicted 3.69m ODN; therefore, the meteorological surge effect during the recorded event was 1.53m.

Sea level rise

16.6.16 The above data do not allow for sea level rise in the future. In order to take into account future sea level rises, and given an assumed engineering design standard of 50 years from 2023, the latest UKCP18 (Ref 16-21) relative sea level research and assuming a Representative Concentration Pathway (RCP) 8.5 (95%ile) scenario will add 0.52 m to the water levels provided in **Table 16.4**.

Flows

16.6.17 Flow speed data has been obtained from the United Kingdom Hydrographic Office (UKHO) Admiralty Tidal Diamond, located within the main channel, approximately 2km up-estuary of the Project. The variation in the tidal flow conditions is provided in **Table 16.5**. Bespoke, site-specific hydrodynamic information is presently being collected and will be used to provide a more detailed description of the tidal flow conditions within the ES.

Table 16.5: Tidal flow conditions from the closest Admiralty Tidal Diamond (Ref 16-16)

Time (hours)	Direction (going to °N)	Spring rate (m/s)	Neap rate (m/s)
-6	132	1.30	0.41
-5	239	0.10	0.10
-4	303	1.10	0.57
-3	305	1.70	0.87
-2	314	1.60	0.87
-1	315	1.50	0.57
HW	319	0.67	0.15
1	122	0.67	0.36
2	133	1.70	0.72
3	129	2.10	1.20
4	132	2.30	1.40
5	126	1.80	1.30
6	132	1.50	0.82

16.6.18 The predicted flow data reveals that the flow regime fronting Immingham is generally rectilinear, with flows aligned approximately east-southeast on the ebb to west-northwest on the flood. Peak flows of around 2.1 m/s are predicted during the ebb tide, with notably slower flows on the flood phase of the tide, resulting from the relative effects of the shallow ‘shelf’ of Stallingborough Flats and the drag effects from IOT.

Waves

16.6.19 From available data, the wave climate across the Project site is generally protected from large waves approaching from the North Sea by a combination of sheltering effects (from Spurn Head and the various banks and channels within the outer parts of the Humber Estuary).

16.6.20 Measured data from the Project oceanographic survey campaign is being collected and will be used to provide a more detailed description of the local wave climate within the ES.

Geology and sediments

16.6.21 The underlying solid geology of the Humber is Upper Cretaceous Chalk. Locally there are two formations: Flamborough Chalk and Burnham Chalk. The younger Flamborough Chalk has identifiable bedding surfaces, distinct marl bands and is without flint. The underlying Burnham Chalk, which subcrops along the eastern part of the site, is thinly bedded and laminated and contains continuous flint bands. The Port of Immingham is located at a point where the Burnham Chalk Formation is not covered by the Flamborough Chalk Formation (Ref 16-18).

16.6.22 The chalk surface is characterised by a highly fractured zone created by glacial and periglacial processes, and overlain by Pleistocene deposits of Glacial Till. These glacial and post-glacial sequences are subsequently overlain by fine-grained (Clay and Silt) Tidal Flat Deposits.

16.6.23 The Humber lies in a complex of solid and superficial geology which can be simplified into three groups: the pre-Quaternary, the glacial (or Quaternary) and Post Glacial (or Holocene).

16.6.24 The estuary upstream of the Humber Bridge represents an older estuary system formed in the last interglacial (120,000 to 80,000 years Before Present) with the estuary mouth at this time being located near the current Humber Bridge. Downstream of this point, the estuary is more recent in geological terms, the channel having formed in immediate post glacial times as melt water cut down through glacial till deposits. During the post glacial period of Sea Level Rise (SLR), the former river channel underwent marine transgression and became subject to estuarine sedimentation.

16.6.25 The sediment budget of the Humber Estuary has previously been informed, by historic analysis of data between 1946 and 2000 (comprising approximately three complete nodal tidal cycles) (Ref 16-19). It is noted that there is a high degree of variability in the underlying data, so regression coefficients calculated during the analysis are poor (although the relationships are statistically significantly different from ‘no trend’). The three main sediment sources for the Humber Estuary are its tributaries, the North Sea (in the form of background suspended sediment) and the eroding Holderness coast. The exchange between the rivers and the sea is an order of magnitude smaller than the flux of sediment through the mouth on each tide and the inputs and outputs on each tide are very much smaller than the volume of sediment held in suspension and continually moving within the Estuary. A summary of the sediment budget is provided in **Table 16.6**.

Table 16.6: Net sediment budget model for the Humber Estuary (Ref 16-19) (based on analysis of data between 1946 and 2000)

System Element	Sediment load and rate of exchange with the Estuary (+ve indicates an input; -ve indicates a removal) (tonnes per tide)
Humber Estuary	1.2×10^6 tonnes

System Element	Sediment load and rate of exchange with the Estuary (+ve indicates an input; -ve indicates a removal) (tonnes per tide)
River inputs	+335
Intertidal accretion	-4
Subtidal erosion	+145
Cliff erosion	+7
Saltmarsh deposition	-11
Met marine exchange	-472
Average tidal flux	$\pm 1.2 \times 10^5$

16.6.26 The bed sediments within the vicinity of the study area are understood to be a mixture of muds and sands. Previous sampling in the Immingham area has also identified the potential for chalk outcrops at depth. The benthic sampling, undertaken during July 2022 as part of the Project study, collected eight sediment samples within, and adjacent to, the proposed berth dredge (see **Figure 16.3** (PEI Report, Volume III) for locations). The bed samples were subsequently analysed for PSD, in order to characterise the bed material across the site. The majority (five of the eight samples) are classified as sandy Mud (Ref 16-20), with the remainder comprising Mud (see **Figure 16.3** (PEI Report, Volume III) for the PSD of the site and **Table 16.7** for summary PSD information). Previous sampling has also collected grab samples across the two disposal sites (HU56 and HU60). PSD information for these samples (see **Figure 16.3** (PEI Report, Volume III) for locations) are also provided in **Table 16.7**, revealing a mixture of sediment type, with varying proportions of sand, mud and gravel.

16.6.27 Across the eight sediment samples collected as part of the baseline studies carried out for the Project, the average bed composition is 76% mud, 24% sand and no gravel material. Within the proposed dredge pocket, these average values shift slightly towards the coarser particles with 69% mud and 31% sand. As noted above, the majority of locations (all within the proposed dredge pocket) are categorised as ‘sandy Mud’ (Ref 16-20), with locations 1, 2 and 3 (inshore of the dredge pocket) defined as ‘Mud’.

16.6.28 Measurements of SSC previously collected from the Immingham area, show that during ebb tides peak SSC can vary from a few hundred mg/l to over 1,000mg/l, during larger spring tides. The SSC levels are also generally higher on spring tides (approximately double the concentrations observed on neap tides) and during the winter months, compared to summer months. The Project oceanographic survey will collect information on suspended sediments, which will be used to detail the local characteristics withing the ES.

Table 16.7: Particle size distribution across the Project and disposal sites

Sample	Percentage composition (%)			Sediment description*	Mean grain size (d50) (µm)
	Mud	Sand	Gravel		
1	96.69	3.31	0.0	Mud	7.8
2	94.11	5.89	0.0	Mud	8.2
3	96.32	3.68	0.0	Mud	7.0
4	71.10	28.90	0.0	Sandy Mud	20.1
5	57.35	42.65	0.0	Sandy Mud	27.7
6	63.76	36.24	0.0	Sandy Mud	23.6
7	71.51	28.49	0.0	Sandy Mud	17.9
8	55.43	44.57	0.0	Sandy Mud	30.6
HU56_01	0.0	100.0	0.0	Sand	159.0
HU56_02	1.6	84.0	14.4	Slightly Gravelly Muddy Sand	186.1
HU56_03	37.1	16.2	46.6	Muddy Gravel	83.8
HU56_04	16.3	12.1	71.5	Gravelly Mud	17.7
HU56_05	18.7	80.1	1.2	Gravelly Sand	707.9
HU56_06	35.0	17.0	48.0	Muddy Gravel	73.7
HU60_01	0.0	100.0	0.0	Sand	230.7
HU60_02	0.0	100.0	0.0	Sand	227.7
HU60_03	0.4	61.7	37.9	Slightly Gravelly Muddy Sand	148.1
HU60_04	0.0	100.0	0.0	Sand	232.7
HU60_05	0.0	100.0	0.0	Sand	202.1
HU60_06	0.0	100.0	0.0	Sand	223.6
* Sediment description after Ref 16-20					

16.6.29 In addition to the bed sampling described above, a full-spread geophysical survey is also planned across the Site. Once completed, these survey data will be used to update the general description of the sub-bottom geology, provided below.

16.6.30 Three seabed sediment classifications have been identified from existing, available Side Scan Sonar and Multibeam Echo Sounder data across the wider Immingham region: silt/mud, muddy sand, and firm clay. Silt/mud is the dominant sediment type. Muddy sand is present further to the north, in an area which also hosts mobile bedforms (geological features that develop at the interface between the seawater and mobile element of the seabed). Firm clay is present towards the south-east and presents as positive relief exposure at the seabed.

16.6.31 Four main types of sub-surface units have been identified, also with sub-units. The geological model has been informed by background site information and geotechnical work carried out previously at, or near to, the survey area. The uppermost unit is comprised of alluvium deposits that can be further subdivided into surficial sediments composed of soft silt/mud with a depth range between 0 to 3.0m below seabed (BSB).

16.6.32 The alluvium is composed of a mix of fluvial sediments comprised of sands, gravels, and clays. The unit presents a complex structure of channelisation and subsequent sediment fill. The base of the alluvium sediments (as a whole) range between 0.8m and 9.1m BSB.

16.6.33 A bright reflector was identified in the upper sub-surface of much of the survey site. This reflector has been interpreted as a layer of organic sediment due to severe acoustic attenuation of the seismic data and by reference to historical borehole logs. All subsequent horizon interpretations have been limited by the presence of the organic sediment layer that attenuates the underlying reflectors, making them uninterpretable across certain areas of the wider region.

16.6.34 A layer of boulder clay underlies the alluvium, which has been interpreted as the “upper boulder clay” unit. The upper boulder clay ranges between 0m and 20.0 m BSB. Beneath the boulder clay lies a horizon interpreted from geotechnical data as inter-glacial clays. This horizon ranges between 4.0m and 25.6m BSB. A second layer of boulder clay has been interpreted as the “lower boulder clay” unit and is intermittently interpreted between 8.7m and 37.5m BSB. The bedrock has been identified as chalk (from geotechnical data) and has been intermittently observed in the seismic data at depths between 15.4m and 41.5m BSB. The bedrock level appears to be dipping downwards towards the north-western edge of the study area.

Future Baseline

16.6.35 Hydrodynamic and sedimentary processes will continue to be influenced by natural and human-induced variability, ongoing cyclic patterns and trends (e.g., ongoing maintenance dredging and disposal) with or without the Project.

16.6.36 The future baseline would also be influenced by climate change and, in particular, increased rates of mean sea level rise. Projections of change for Immingham up to 2100 are 0.99m (based on UKCP18 RCP 8.5 95%ile climate change scenario). Water levels in the future, as now, would also be affected by unpredictable surge and weather-related events.

16.7 Design, Mitigation and Enhancement Measures

Embedded Mitigation Measures

16.7.1 The Project has been designed, as far as possible, to avoid and minimise impacts and effects on physical processes through the process of design development, and by embedding mitigation measures into the design, such as minimising the dredge requirements as far as possible.

Standard Mitigation Measures

16.7.2 Standard mitigation measures will be undertaken to manage commonly occurring environmental effects. Although these are not likely to alter the assessment conclusions, they are considered to be standard good practice and are taken account of in the initial impact assessment. In terms of physical processes, the following standard mitigation measure will likely be recommended:

a. **Even disposal deposition**: The targeting of disposal loads in the central/deeper areas of the disposal sites (HU056 and HU060) will be undertaken to reduce depth reductions. This will minimise the initial reduction in water depth and any environmental changes at these disposal sites.

16.8 Potential Impacts and Effects

16.8.1 This section identifies the potential likely effects on the physical processes receptors as a result of the construction and subsequent operation of Project (**Figure 16.4** in PEI Report, Volume III).

16.8.2 Cumulative impacts on physical processes that could arise as a result of other developments and activities in the Humber Estuary are considered as necessary as part of the cumulative impacts and in-combination effects assessment (**Chapter 25: Cumulative and In-Combination Effects**).

16.8.3 The preliminary assessment has identified potential likely impacts on physical processes as a result of the construction and subsequent operation of the Project.

16.8.4 These impacts are associated with:

a. Changes in SSC and sedimentation from the capital dredge and disposal and piling.

b. Changes in hydrodynamics and waves from the presence of marine facilities (approach jetty, jetty platform and dredge pocket).

c. Indirect impacts on existing features, including marine infrastructure, outfalls and estuary banks and channels as a result of changes in hydrodynamics, waves and associated sediment transport pathways.

d. Changes in SSC and sedimentation from maintenance dredging during operation.

Construction

16.8.5 This section contains an assessment of the potential impacts of the construction phase of the Project. It should be noted that the construction of the Project may be completed in a single stage, or it may be sequenced such that the construction of Berth 2 takes place at the same time as operation of Berth 1 (see **Chapter 2: The Project**). Numerical modelling is based on a scenario with all elements of infrastructure in place including both berths and is considered a 'worst-case' scenario in terms of potential impacts on hydrodynamics. Capital dredging (and associated disposal activity) will be undertaken together at one time, before operation of Berth 1 commences. Therefore, for all impact pathways the physical processes assessment will not be altered by a single or sequenced construction period.

16.8.6 At this preliminary stage the following construction activities and impacts have been identified and considered:

a. Capital dredge and disposal and piling works:

   i Increased SSC and potential sedimentation over the extent of the disturbance plume as a result of the construction of the new jetty(s) (piling) and capital dredging works.

   ii Increased SSC and potential sedimentation as a result of the deposit of capital dredge material at a licensed offshore disposal site(s).

   iii Changes in seabed bathymetry and composition as a result of deposition of dredged/disposal material within the area of the respective plumes.

b. Changes in local flow speeds (and potential impact on local sediment dynamics) as a result of construction vessel activity (ship wash, vessel propulsion etc.).

Capital dredge and disposal and piling - potential impact on SSC and sedimentation

16.8.7 The disposal of dredged material at sea associated with the Project would be fulfilled at licensed disposal sites HU056 (for any inerodible boulder/glacial clay) and HU060 (for any sand/silt (alluvium) material) (see **Chapter 2: The Project**).

16.8.8 The potential impact of dredge arisings (and spoil from removal to licensed disposal sites) on SSC and sedimentation has been assessed. However, the disposal activity is considered to result in a larger extent and magnitude of impact than that arising from the dredge (as a result of the relative volumes and methods). The approach uses the dredge volumes provided by the project engineers and expert knowledge of the likely dredging process and of the availability of open disposal sites. The assessment is informed by application of the calibrated numerical hydrodynamic modelling tool, which drives a Danish Hydraulic Institute (DHI) particle tracking module.

16.8.9 It is anticipated that most of the dredging for the berth pocket would be undertaken by a backhoe dredger and would be supported by split barges on a continuous cycle to the disposal grounds. This dredging method has been assessed here as a worst-case for potential impact on SSC (resulting from release of material throughout the water column during both dredging and disposal – see assumptions in **Section 16.2**). The number of barges would be determined by the barge loading time and the time of transit to and from the disposal grounds so that the backhoe dredger is never stood idle, meaning the works would be a 24/7 operation until dredging is complete. The assessment is based on barge access to the disposal sites being achieved throughout the full tidal cycle (see **Paragraph 16.4.5**). Current dredge volume estimates (based on the latest available site-specific geotechnical and geophysical information) are for a total of approximately 100,000 m^3 of material.

Dredging of the proposed berth(s) and associated disposal at HU060

16.8.10 Based on previous experience, the following assumptions have been made in relation to the berth dredge:

a. Backhoe bucket size of 8 m^3;

b. Average bucket cycle time of 2 minutes;

c. Working capacity of barge = 950 m^3;

d. A continuous barge operation would provide maximum production and greatest potential for magnitude in plume; and

e. Typical rates, vessel speeds and distance to disposal site have been used to calculate typical dredge cycle times.

16.8.11 In addition, the following details have also been assumed in respect of the plume assessment, based on an understanding of the method and equipment to be used:

a. Distance from dredge to disposal site is approximately 1.1 nautical miles and the assumed load service speed is 8 knots;

b. Barge deposit time is 10 minutes;

c. Characteristic sediment distribution is informed by the bed sampling (detailed in **Table 16.7** to this chapter, with a mean grain diameter of around 20 µm;

d. Inputs to the plume modelling from the dredge are applied both at the bed and also uniformly through the water column, arising from bucket lowering, bed ripping, water column wash and slewing (breaking the water surface);

e. Inputs to the plume modelling from the deposit at the disposal site are applied both at the bed (from the deposit) and also just below the surface (from the initial release, based on the loaded draught of the barge); and

f. At the disposal site, the sediment predominantly falls to bed as a density current and is then available for onward advection through bed erosion processes.

16.8.12 Using the above assumptions, the model assesses the repeating cycle of (dredging at the planned berth pocket and subsequent) disposal at HU060. Consequently, the basis of the assessment assumes continuous dredging (throughout the modelled period) at the proposed berth location(s) and a disposal (over a 10-minute period) at HU060 every four hours.

16.8.13 The deposits at HU060 have been assessed, as this site is likely to receive the vast majority of the more unconsolidated dredged material. If required, HU056 will be used for the disposal of any inerodible boulder clay, which is considered likely to remain on the bed, without resulting in a significant plume of material. As a consequence, disposal activities at HU056 have not been modelled as the impacts are considered to be well within the magnitude and extent of the envelope of impact defined by the assessment of material at the HU060 disposal site (included in this assessment).

Spatial dispersion of dredge plume and sedimentation

16.8.14 Following the repeating schematic dredge cycle the particle tracking model has been run with sequential dredge, disposal, dredge, cycles. The initial dredge commences during a mean spring tide and the cycle repeats for the remainder of the model run period. Dredge locations within the berth pocket are switched between either end of the berth pocket, whilst disposal inputs are to the centre of the HU060 disposal site.

16.8.15 **Figure 16.5** (PEI Report, Volume III) shows the maximum spatial extent of the disposal SSC plume at HU060 over peak flood and peak ebb tidal flows (on a spring tide). The maximum extent of excess SSC resulting from the assessed repeating ‘dredge > disposal…’ cycle is shown in **Figure 16.6** (PEI Report, Volume III).

16.8.16 For dredge arisings disposed at the HU060 site, it is anticipated that material will initially remain in suspension (when deposited during flood or ebb tidal flows), before settling to the bed during slack water around high water (HW) and low water (LW) periods. Once deposited to the bed, the material will return to the background sedimentary system for subsequent transport under flood or ebb tidal flows. Maximum SSC levels are associated with the disposal activities (with relatively small increases in SSC arising from the dredge itself). Peak excess SSC levels resulting from the disposal activities are around 600-800 mg/l at the spoil ground, reducing to typically 100-200 mg/l with distance from the source. Upstream of Hull, maximum SSC levels are lower; generally, between 20 and 100 mg/l, as the tidal excursion from the disposal site limits the extent of the resultant plume.

16.8.17 In practice, due to the high magnitude of (and wide envelope of variability in) background SSC levels, the predicted increase in concentrations resulting from the disposal activities is likely to become immeasurable (against background) within approximately 1 km of the disposal site. Furthermore, the effects of the proposed disposal operations are considered to be no different to those arising from the ongoing maintenance dredge/disposal activities that are carried out at the adjacent Immingham berths. The measurable plume from each disposal operation is only likely to persist for a single tidal cycle (less than 6 hours from disposal). After this time, the dispersion under the peak flood or ebb tidal flows means concentrations will have reverted to background levels. Increased concentrations arising from the dredge operations are of lower magnitude and persist over a shorter distance (and time) than that from the disposal.

16.8.18 Associated sedimentation (**Figure 16.6** (PEI Report, Volume III)) to the bed extends up- and down-estuary from the disposal site. Peak sedimentation depths are around 4-6 mm within a distance of around 4 km from the disposal site. At the dredge location, increased sedimentation above 3 mm is predicted within around 500 m (aligned to the flow vectors) up- and down-stream of the dredged pocket. Outside of these areas, the majority of deposition levels across the study site are less than 1 mm. Once on the bed, the deposited material returns to the background system to be put back into suspension on subsequent peak flood or ebb tide to be further dispersed.

16.8.19 Example timeseries plots of predicted excess SSC and associated sedimentation (from the combined dredge/disposal operations) is provided in **Figure 16.7** (PEI Report, Volume III) for two locations – one just up-estuary and one just down-estuary of the HU060 disposal site. In each case, peak SSC and sedimentation values are predicted at the disposal site whilst, at locations approximately 1.5 km up- and down-estuary, the timeseries plots show the temporal nature of the excess material. Each disposal results in peak SSC of around 100-200 mg/l at the selected locations (approximately 1.5 km from the disposal source). Each peak in SSC generally persists for a single timestep before the tidal forcing transports the plume further up/down estuary on the prevailing flood/ebb tide, respectively. Due to the timing of successive disposal events, there is no evidence of cumulative increases in SSC (i.e. the impact from each disposal is dispersed sufficiently before the next disposal, such that there is no predicted positive trend in excess SSC with sequential disposal events).

16.8.20 Associated with this, each disposal operation results in sedimentation of around 1-2 mm at locations around 1.5 km from source. Once deposited, this material remains on the bed during slack water periods, before being put back into suspension on the subsequent flood or ebb tide. Thus, material is returned to the existing (baseline) sediment regime, retained within the wider Humber Estuary system following disposal at HU060.

16.8.21 It should be noted that the map plots in **Figure 16.5** and **Figure 16.6** (PEI Report, Volume III) do not show the instantaneous SSC and sedimentation levels at any given point in time, rather they show the maximum SSC and sedimentation value at any location during the complete model run time. As a result, the plots show the extent of overall effect from the dredge and the disposal within the estuary, without reference to how soon after commencement of operations they occur, nor how long these values persist at any given location. In contrast, the successive temporal plots provided in **Figure 16.8** (PEI Report, Volume III) show the instantaneous extent and magnitude of excess SSC (and associated sedimentation) following a number of consecutive disposal events.

Assessment of exposure to change

16.8.22 The greatest increase in SSC from the piling, dredging and disposal activities will occur during the barge depositing material at the licensed disposal site. Material within the passive plume will be dispersed throughout the water column as the load drops to the bed, with the potential to be transported up- and down-estuary through the full tidal excursion (dependent on tidal state at the point of release). Initial SSC values within the dynamic plume will be very high but, given the very high natural levels within the estuary, excess levels are likely to be reduced to below natural storm disturbance conditions very quickly (and before the next disposal operation commences four hours later). This is typically the same scenario that occurs for the existing maintenance dredging of the local Immingham berths, which has been undertaken frequently (multiple times during the year) since the berths were first implemented.

16.8.23 At the disposal site, the effect of deposition of capital dredge arisings will be similar to that which already occurs as a result of ongoing maintenance dredging and disposal. Local changes to the bathymetry (as a result of material disposal to the bed) within the disposal site will be small in the context of the existing depths. As is currently the practice, disposal activity will be targeted to the deeper areas within the site, ensuring that bed level changes are not excessive in any one area, thus minimising the overall change. As a result, associated changes to the local hydrodynamics (and sediment transport pathways) will be negligible. Ongoing monitoring of depths within the disposal site (an activity already undertaken to assess bed level changes as a result of existing dredge disposal activities) will continue into the future. Consequently, the impact of the disposal from both capital and future maintenance dredging of the berth(s) will be monitored.

16.8.24 The local hydrodynamics, the existing (background) SSC levels within the wider Humber Estuary and the proposed dredge and disposal works have all been considered within this assessment. Overall, the increase in SSC and potential sedimentation in the marine environment is likely to be the same as that which already occurs from existing maintenance dredging in the area (which has been occurring for many years). Moreover, peak increases will remain within the envelope of natural variability in background SSC. As a result, the probability of occurrence is considered high although the magnitude of change is assessed as small, resulting in an overall **low** exposure to change.

Construction vessel activity – impacts on local hydrodynamics and sediment transport arising from ship wash and vessel propulsion

16.8.25 It is understood that the piling and decking for the approach jetty and piers are being constructed using land-based plant and equipment, and by quasi-stationary floating and jack-up barges. Consequently, the only vessels associated with the construction phase are the dredgers and barges for the capital works and slow-moving jack-ups that, once in position, effectively remain stationary whilst carrying out the works. The majority of the material will be removed with a backhoe dredger to a hopper (for subsequent disposal). Whilst the optimal size of the dredging plant will need to be determined by the specialist dredging contractor, the backhoe method effectively uses stationary plant to dredge a defined area, with the plant moving across the dredge site until all the required material has been removed. In this way, the construction vessel movements are generally limited in frequency to the movements across the dredge area, rather than being continuous throughout dredge operations. Due to water depths across the wider area, it is further considered likely that dredging plant will access the berth pocket from offshore, meaning that any ship wash and vessel propulsion effects on local flow speeds are anticipated to occur away from the adjacent foreshore.

16.8.26 Some material may also be removed by trailer suction hopper dredger (TSHD) depending on the sediment conditions and the availability of TSHD dredgers. Should this be the case, then deeper water depths will be required for the vessel to operate in. As described above, this will lead to potential ship wash and vessel propulsion impacts (to local flow speeds) being limited in extent to the deeper offshore areas on the estuary-side of the berth(s).

Assessment of exposure to change

16.8.27 There is predicted to be a generally limited temporal impact from the construction vessel movements (with infrequent movements across the berth pocket), coupled with the likely extent of effect being limited to the deeper, offshore side of the Site. As a result, it is unlikely that there would be any notable impact on local flows across the adjacent intertidal area and, by association, no likely impact on local accretion or erosion processes. Consequently, the probability of occurrence is considered medium although the magnitude of change is assessed as small, resulting in an overall **low/negligible** exposure to change.

Operation

16.8.28 This section contains an assessment of the potential impacts as a result of the operational phase of the Project. The following operational elements and impacts will be assessed:

a. Marine facilities (approach jetty and dredge pocket):
   - i Local changes to hydrodynamic regime (flow speed and direction) as a result of the piers (piling) and the implementation of the new berth pocket.
   - ii Associated local changes to the sediment transport pathways, as a result of localised changes to the driving hydrodynamic (and wave) forcing.
   - iii Local changes to the wave regime, as a result of the piers (piling) and the implementation of the new berth pocket.
   - iv Potential impacts on existing features, including existing marine infrastructure, outfalls and estuary banks and channels.

b. Maintenance dredging - potential impact on SSC and sedimentation:
   - i Increased SSC and potential sedimentation in the area of dispersal plume as a result of maintenance dredging.
   - ii Increased SSC and potential sedimentation as a result of deposition of maintenance dredge material at a licensed disposal site.
   - iii Changes in seabed bathymetry and composition as a result of deposition of dredged/disposed maintenance dredge material.

16.8.29 The pathways of change as a result of the operational phase of the Project, including changes to flow regime with a vessel at the berth(s), and changes to the sediment transport regime to determine potential effects on sedimentation rates (and hence the potential for maintenance dredging) are currently being assessed and will be reported within the ES.

Marine facilities (approach jetty, jetty platform and dredge pocket) - potential impact on hydrodynamics

16.8.30 A preliminary assessment of impacts on hydrodynamics has been carried out using numerical modelling tools and conceptual analysis (see **Paragraph 16.1.7**). The modelling has been completed using an updated version of the existing calibrated and validated MIKE FM HD model of the Humber Estuary. The updated model mesh has been refined around the study area and adjacent coastline.

16.8.31 The bathymetric datasets used in the creation of the model mesh consist of a combination of survey data collected for the Project, existing data provided by the Applicant in and around Immingham, along with topographic LiDAR data from the Environment Agency Open Data portal.

16.8.32 The updated model has been subject to new calibration and validation using survey data for the local area. Calibration and validation have been undertaken over a spring and neap tide. Full details of the model setup, calibration and validation are provided in **Appendix 16.A** (PEI Report, Volume IV).

16.8.33 Although not specifically shown on a figure within this assessment, it should be noted that the assessment of the Project on local hydrodynamics reveals no impact on water levels across the near- or far-field area. Consequently, water levels across the existing berths are not predicted to change as a result of the Project.

16.8.34 The predicted impacts on the local flow regime, obtained through hydrodynamic modelling of the area, are summarised both spatially, in the immediate vicinity of the approach jetty, jetty platform and dredge pocket, and temporally at a series of point locations identified as strategic locations and areas of greatest importance.

16.8.35 The spatial hydrodynamic effects of the marine facilities (approach jetty, jetty platform and berth pocket) are shown in **Figure 16.9** (PEI Report, Volume III) for the approximate time of peak flood and ebb spring flows. Initial results of the hydrodynamic modelling show that the Project causes generally small impacts, confined predominantly to the vicinity of the structure and adjacent Immingham Oil Terminal (IOT).

16.8.36 During the flood tide (**Figure 16.9** (PEI Report, Volume III)), the extent of effect as a result of the Project is approximately 3.5 km up estuary from the west edge of the berth pocket, across IOT and Humber International Terminal (HIT). Along IOT, flow speeds are reduced by up to 0.34 m/s on the eastern end of the jetty, and by 0.18 m/s at the western end. By the time flows reach HIT, the flow speed reductions are approximately 0.08 m/s. At the western edge of the berth pocket, flows are reduced by up to 0.48 m/s, this quickly reduces to a lowering of 0.2 m/s at the eastern end of the jetty platform. Small increases in flow speeds are seen just to the north of the eastern end of the jetty platform, and to the south along the shore frontage of up to 0.08 m/s.

16.8.37 These changes in flow speed on the flood tide are relatively small with regards to the baseline flow speeds. Baseline flows are between 1.2 and 1.3 m/s in the area of interest. As a result, maximum predicted changes in flow speed as a result of the Project generally tend to be limited in extent to the dredge pocket itself and are around -30% of baseline flow speeds. Further afield, changes remain constrained to the area adjacent to the berth(s), with flow speed changes generally around -5%.

16.8.38 On the ebb tide (**Figure 16.9** (PEI Report, Volume III)), the assessment shows a similar pattern of change to the flood tide, however, the reduction in flow speed occurs for approximately 3km down estuary from the eastern end of the jetty platform. Here, there are flow speed reductions of up to 0.55m/s. However, this quickly reduces to a 0.25 and 0.1m/s reduction 500 m and 1 km downstream, respectively. In the berth pocket itself, flow speeds are reduced by up to 0.3m/s. South of the Project, flow speeds are slightly increased by less than 0.1m/s moving towards the shoreline.

16.8.39 As with the flood tide, these changes in flows speed are relatively small in relation to the baseline flows speeds. Baseline flows vary from approximately 1.6m/s to approximately 1.7m/s in the area of interest. As a result, predicted reductions in ebb flow speed within the dredge pocket generally tend to be around -18% of baseline flow speeds. To the east of the jetty platform, flow speeds reduce by up to 30% of the baseline, reducing to -5% 1km downstream of the Project.

16.8.40 Timeseries plots have been provided to illustrate a predicted temporal change throughout the spring tide at key locations. These are provided in **Figure 16.10** to **Figure 16.12** (PEI Report, Volume III).

16.8.41 At P1 (**Figure 16.10** (PEI Report, Volume III)), approximately 3km downstream of the project, changes in flow speeds on the flood tide would be negligible, and on the ebb tide, flow speeds would be reduced by approximately 0.05m/s.

16.8.42 At P2 and P3 (**Figure 16.10** (PEI Report, Volume III)), within 500m of the eastern end of the jetty platform, changes in flow speed on the flood tide would again be negligible. On the ebb tide, flow speeds at P2 are reduced by up to 0.3m/s, whilst at P3, flows are reduced by up to 0.5m/s.

16.8.43 Within the dredge pocket (locations P4 and P5), a general decrease in flow speeds is predicted (**Figure 16.10** and **Figure 16.11** (PEI Report, Volume III)) on the flood tide at both locations, flow speeds are reduced by up to 0.3m/s. On the ebb tide, flows speeds at both locations are reduced by up to 0.15m/s.

16.8.44 At P7 and P8 (**Figure 16.11** (PEI Report, Volume III)), in front of Immingham Oil Terminal (IOT), and P9 (**Figure 16.11** (PEI Report, Volume III)) (500m northwest of IOT) flow speeds are reduced by up to 0.25m/s on the later stage of the flood tide. On the ebb tide, changes in flow speeds are negligible.

16.8.45 At P10 (**Figure 16.12** (PEI Report, Volume III)), approximately 3.5km upstream of the Project in front of the Humber International Terminal, flow speeds on the flood tide are reduced by less than 0.05m/s, whilst changes in flow speed on the ebb tide are negligible.

16.8.46 At P6, P11 and P12 (**Figure 16.12** (PEI Report, Volume III)), south of the Project, just in front of the foreshore, flow speeds are slightly increased by up to 0.05m/s on both the flood and ebb tides, although changes in flow speeds on the ebb tide at P12 are negligible. At each of these locations, associated changes to bed shear stress are negligible in the context of the thresholds of motion for the typical bed material. Whilst modelling of the potential for changes to sediment transport pathways remains ongoing (with results to be provided in the ES), it is currently anticipated that any changes to sediment erosion and accretion along the adjacent foreshore will be negligible.

Inclusion of vessels on-berth

16.8.47 The assessment of changes to hydrodynamics, as a result of vessels on-berth, has not yet been completed and results will be included in the ES. However, given the distance offshore, the water depths within the berth(s), the proximity to the main deep-water channel and the adjacent operational IOT berth(s), it is anticipated that the inclusion of vessels on berth at the Project will result in similar impacts to those described above.

Assessment of exposure to change

16.8.48 Marginal changes to hydrodynamics (local flow speed) are likely to result from the Project within, and adjacent to, the proposed berth pocket. Slight changes in flow speed are predicted to extend up-estuary to Immingham Outer Harbour and IOT and down-estuary. The largest predicted magnitude of change is anticipated within the berth pocket itself and the eastern end of the jetty platform. The probability of occurrence is, therefore, considered high, although the magnitude of change is assessed as small, giving rise to an overall **low** exposure to change.

Marine facilities (approach jetty, jetty platform and dredge pocket) – potential impact on sediment transport

16.8.49 Changes to the local hydrodynamics, as a result of the Project (as described above) have the potential to affect local sediment transport (i.e., faster flows may increase bed erosion, and lower flows may encourage sedimentation).

16.8.50 To investigate the potential impact of the marine facilities on sediment transport, the movement of fine-grained material (as identified across the Project grab sampling survey) has been investigated using the MIKE Mud Transport (MT) module. The model is driven by the outputs of the hydrodynamic model described above and verified against local dredge records and SSC measurements. The model setup and validation are described in **Appendix 16.1** (PEI Report, Volume IV).

16.8.51 The modelling tool has been applied to model the existing baseline for the Project, and the difference in bed thickness over a 15-day mean spring-neap cycle has been calculated.

16.8.52 **Figure 16.13** (PEI Report, Volume III) shows the predicted change in bed thickness of fine material, as a result of the Project, over a mean spring-neap tidal cycle. It is predicted that the changes in accretion and erosion patterns are generally small in both magnitude and extent. The reduction in flow speeds within the dredged berth pocket and across the leeward side slopes result in associated change to bed shear stress (BSS), allowing for slightly reduced erosion over the baseline condition. This indicates that the berth pocket, once dredged, will likely keep swept clear of deposited material by the flood and ebb tidal flows (in much the same way the existing IOT berths are). Consequently, the need for future maintenance dredging within the new berth pocket is expected to be limited.

16.8.53 In addition to the predicted reduced erosion within parts of the proposed berth pocket, local increases in peak flood and ebb current speed at the landward end of the proposed IGET approach jetty (**Figure 16.13** (PEI Report, Volume III)), result in associated slight increases to BSS. These lead to a slight increase in predicted erosion of the bed at the at the elevation of MLWS, beneath the landward end of the proposed jetty (**Figure 16.13** (PEI Report, Volume III)) shows the difference in bed thickness change against the baseline, with negative values indicating areas of either increased erosion or of reduced accretion). Over a mean spring neap cycle, the predicted erosion is less than 0.05 m, resulting in a potential indirect loss in intertidal area of approximately 0.01 ha. The assessment indicates that once this part of the softer upper layer is removed, the harder, more consolidated, underlayer of bed material is unlikely to erode further. This calculation represents a worst-case assessment of potential elevation changes and has been considered on a precautionary basis. The level of predicted change is at the limit of the accuracy of the modelled data and, in real terms, is likely to be immeasurable against the context of natural variability (as a result of storm events, for example).

16.8.54 Across the wider study area (including the existing berths at IOT, the rest of the intertidal area along the Immingham frontage, the Habrough Marsh Drain and Immingham Sea outfalls, the offshore banks and channels and the wider estuary up- and down-stream), the Project marine facilities have no impact on the existing (baseline) accretion and erosion rates (**Figure 16.13** (PEI Report, Volume III)). Overall, there is predicted to be limited magnitude and extent of predicted change, resulting from the Project (in terms of both hydrodynamics across the range of tidal states and the associated negligible impact on estuary tidal prism and far-field sediment transport pathways). This, coupled with the in-estuary disposal of capital and maintenance dredge material (thus maintaining the sediment as part of the wider estuary sediment budget), indicates that the Project will not result in long-term changes to the wider estuary morphology.

Assessment of exposure to change

16.8.55 Hydrodynamic forcing within (and adjacent to) the Project will only be marginally altered and, therefore, changes in the sediment pathways will be small. Predicted changes to future sediment transport are small in magnitude and limited in extent to the berth pocket and the landward end of the approach jetty. Outside the proposed berth pocket, the Project has limited impact on the baseline sedimentation and erosion rates.

16.8.56 As a result, the probability of occurrence is considered to be high, and the magnitude of change is assessed as small, resulting in an overall **low** exposure to change.

Marine facilities (approach jetty, jetty platform and dredge pocket) - potential impact on waves)

16.8.57 Preliminary impacts on waves have been assessed using numerical modelling tools and conceptual analysis. The modelling has been completed using the existing (updated, as described) calibrated and validated MIKE SW model of the Humber Estuary. The model examines how wave conditions will be affected during extreme and more frequently occurring events.

16.8.58 The model utilises the same bathymetric data as the hydrodynamic model (as described above).

16.8.59 The updated model has been subject to performance checks by simulating wave conditions at the site, over a short period during which waves have been recorded at the site during the Project AWAC deployment (for discrete periods between 2020 and 2022). Full details of the model setup and verification are provided in **Appendix 16.A** (PEI Report, Volume IV).

16.8.60 The assessment of potential wave impacts from the Project has defined a set of wave conditions (including Hs, peak wave period (Tp) and wind speed (WS)), for a range of return periods and for a number of approach directions (described further in **Appendix 16.A** (PEI Report, Volume IV)). These wave events have then been applied to the numerical model under existing (baseline) and scheme scenarios. The predicted differences in modelled wave heights, as a result of the berth pocket dredge, have then be calculated.

Table 16.8: Extreme boundary wave conditions for the Humber Spectral Wave Model

Return period (yr)		North-easterly	Easterly	South-easterly
		All Year	All Year	All Year
0.5	Hs (m)	3.4	2.4	2.4
	Tp (s)	9.0	6.7	5.6
	WS (m/s)	15.0	13.0	15.0
50	Hs (m)	5.2	4.1	4.8
	Tp (s)	11.1	8.7	7.9
	WS (m/s)	23.0	21.0	25.0

16.8.61 The spatial wave effects of the construction of the Project are shown in **Figure 16.14** (PEI Report, Volume III) for each of the events modelled in **Table 16.8**. Preliminary results of the wave modelling show that the Project results in generally small impacts, confined predominantly to the area in the vicinity of the structure.

16.8.62 The greatest effect on wave height for the 0.5-yr, north easterly event is seen at either end of the jetty platform, with reductions in wave height of up to 0.16m at the western end, and 0.14m at the eastern end (**Figure 16.14** (PEI Report, Volume III)). This reduction in wave heights continues south of the jetty platform, towards the foreshore. However, these reductions are small, with a 0.1m reduction immediately south of the jetty platform, reducing to 0.05m a further 500m south of the platform. At the foreshore, wave height reductions are negligible. There is no change to wave heights within the berth pocket. Baseline wave heights for this event tend to be in the region of 1.1 m around the Project. The maximum predicted change in wave height is therefore around -12%. This change is limited in extent to the area immediately around the jetty platform.

16.8.63 For the 0.5-yr, easterly and south easterly event, it is anticipated that the impacts will extend slightly further than those of the north easterly event (**Figure 16.14** (PEI Report, Volume III)). As with the north easterly event, the biggest impact is seen at the eastern and western ends of the jetty platform, with decreases in wave heights of up to 0.2m. The sheltering effect of the Project extends further west, across the IOT and towards Bellmouth. At this point however, wave speed reductions are small. By the time it has reached the most eastern part of IOT, wave heights are reduced by less than 0.05m. Within the berth pocket, wave heights are reduced by less than 0.08m. The baseline wave heights for this event are approximately 1.17 m, with a maximum decrease of 0.2m, which represents a change of around -17 % at the jetty platform. Reductions in wave heights elsewhere represent a change of around -6%.

16.8.64 As with the 0.5-yr event, the greatest effect on wave height for the 50-yr, north easterly event is seen at either end of the jetty platform, with reductions in wave height of up to 0.2m at the western end (10% decrease from the baseline), and 0.18m at the eastern end (9% decrease from the baseline) (**Figure 16.14** (PEI Report, Volume III)). This reduction in wave heights continues south of the jetty platform, towards the foreshore. However, these reductions are small, with a 0.1m reduction (5% relative to the baseline) immediately south of the jetty platform, reducing to 0.08m (4%) a further 500m south of the platform. Towards the foreshore, wave height reductions are less the 0.03m (1.5%). There is no change to wave heights within the berth pocket.

16.8.65 For the 50-yr, easterly event, it is anticipated that the impacts will extend slightly further than those of the north easterly event (**Figure 16.14** (PEI Report, Volume III)). As with the north easterly event, the biggest impact is seen at the eastern and western ends of the jetty platform, with decreases in wave heights of up to 0.3 m at the western end (13% reduction from the baseline), and 0.2m at the eastern end (9% reduction from the baseline). The sheltering effect of the Project extends further west, across the IOT and towards Bellmouth. At this point, however, wave height reductions are small. Along the most eastern part of IOT, wave heights are reduced by less than 0.05m (2%). Within the berth pocket, wave heights are reduced by less than 0.08m (3.5%).

16.8.66 The 50-yr south easterly event is similar in pattern and magnitude of effects on wave height as the easterly event, particularly along the jetty platform. However, due to the higher baseline wave heights for this event, the relative (percentage) decrease in wave height is less than that for the easterly event. At the jetty platform, wave heights are expected to decrease by up to 10%, whilst at IOT and towards the adjacent foreshore, wave heights are expected to decrease by less than 1% compared to the baseline.

Assessment of exposure to change

16.8.67 Marginal changes to significant wave height (Hs) are likely to result from the Project within, and adjacent to, the proposed berth pocket. For the various wave events assessed, slight changes in wave height (typically less than -6% of baseline values) are predicted to extend up-estuary as far as Bellmouth (for a wave event approaching from the southeast). The largest predicted magnitude of change is anticipated in the immediate vicinity of the jetty platforms.

16.8.68 The probability of occurrence is considered high, although the magnitude of change is assessed as small giving rise to an overall **low** exposure to change at this preliminary stage of the assessment.

Marine facilities (approach jetty, jetty platforms and dredge pocket) - potential impact on existing features, including marine infrastructure, outfalls and estuary banks and channels

16.8.69 Identified changes to the existing (baseline) hydrodynamics, waves and associated sediment transport pathways have the potential to impact existing features. Such features, which include existing marine infrastructure, land drainage outfalls and estuary banks and channels, have been identified in the relevant sections above and the potential impact from the Project is summarised here.

16.8.70 Changes to flows and waves are predicted to be generally limited in extent to around the Project marine facilities and in the immediate vicinity. The predicted impacts at the existing marine terminals (including IOT, Humber Sea Terminal, Immingham Eastern and Western Jetties, Immingham Outer Harbour and Immingham Gas Terminal) are (where predicted) generally small in magnitude. This is also the case for the adjacent foreshore areas fronting the project site, which include a number of outfalls. With distance from the Project, the predicted impacts reduce further and are not predicted to occur over the far-field region. Changes to local and regional sediment transport pathways have been modelled and are only predicted in close proximity to the marine elements of the Project, meaning the existing banks and channels of the wider Humber estuary are not predicted to be impacted by the development.

Assessment of exposure to change

16.8.71 Changes to flows and waves are likely to result from the Project marine facilities within, and adjacent to, the proposed berth pocket and jetty infrastructure. These changes are predicted to be greatest in closest proximity to the Project, reducing in magnitude with distance. Associated impacts to sediment transport pathways are currently being assessed and will be included in the ES. However, given the small extent and low magnitude of effect on the driving hydrodynamics, coupled with the relatively stable nature of the estuary morphology across the near-field study area, it is presently considered that the predicted changes arising from the Project will not affect the existing, longer-term cyclic patterns in the estuary banks and channels.

16.8.72 Across the near-field, the probability of occurrence is considered high, although the magnitude of change is assessed as small giving rise to an overall **low** exposure to change. Across the far-field, the probability of occurrence is considered low, and the magnitude of change is assessed as negligible, giving rise to an overall **negligible** exposure to change.

Maintenance dredging - potential impact on SSC and sedimentation

16.8.73 The assessment of impacts on local and regional sediment transport pathways is currently underway and the findings will inform the potential requirement for future maintenance dredging. Once the modelling is complete, this assessment will be undertaken and included in the ES. However, it is considered that any maintenance dredging (if required) will be of a considerably smaller volume than that assessed above for the capital works. In fact, the adjacent berths at IOT currently require minimal maintenance dredging as the berths are kept clear of accreted material by the flows through the main deep-water channel.

16.8.74 Outside of the berth(s), and particularly within the existing Immingham berths, the predicted changes to flow speed and wave height are generally negligible. Whilst the detailed assessment of changes to sediment transport is underway and will infirm the assessment within the ES, it is currently considered unlikely that the proposed works for the Project would have any noticeable impact on existing maintenance dredge requirements along the remainder of the Immingham frontage. This is particularly true considering the range of natural variability in the annual maintenance requirements within the existing berths.

Assessment of exposure to change

16.8.75 This assessment will be updated within the ES, following completion of the sediment transport modelling. At this stage (as a result of the predicted changes to the driving hydrodynamics and the existing nature of sedimentation and dredging requirements in adjacent (existing) berths), it is considered that any future maintenance dredging (if required) will result in smaller changes in SSC and sedimentation compared to the capital dredge. Furthermore, the predicted impacts from future maintenance dredging (if required) will be similar to that which already arises from the ongoing maintenance of the existing Immingham berths. As a result, the probability of occurrence is presently considered medium although the magnitude of change is assessed as small, resulting in an overall **low/negligible** exposure to change.

16.9 Preliminary Assessment of Residual Effects

Construction

16.9.1 None of the impact pathways identified for physical processes are expected to give rise to a measurable exposure to change. All potential impacts during construction, at this preliminary stage, and based on the current project design, have been assessed as **not significant**.

Operation

16.9.2 All potential impacts on impact pathways identified for physical processes during operation, at this preliminary stage, and based on the current project design, have been assessed as **not significant**.

Decommissioning

16.9.3 The DCO will not make any provision for the decommissioning of the marine infrastructure above and below water level. This is because the Project would, once constructed, become part of the fabric of the Immingham port estate and would, in simple terms, continue to be maintained so that it can be used for port related activities to meet a long-term need. On this basis, potential effects on physical processes from decommissioning have been scoped out.

16.9.4 The final outcomes of the likely significant effects of the Project on physical processes will be reported within the ES.

16.10 Summary of Preliminary Assessment

16.10.1 A summary of the impact pathways that have been assessed, the identified residual impacts and level of confidence are presented in **Table 16.9** to this chapter based on the current understanding. These will be updated in the ES, following completion of the outstanding modelling. This assessment has focussed on the potential ‘exposure to change’ resulting from the impact pathways that have been scoped into the assessment.

16.10.2 Overall, the physical processes changes brought about by the construction and operation of the Project are currently considered small in both magnitude and extent and the resultant exposure to change assessed as low.

Table 16.9: Summary of potential impact, mitigation measures and residual effects

Receptor	Impact Pathway	Exposure to change	Mitigation Measure	Residual Effect	Confidence
Construction Phase					
Physical processes	Increased SSC and potential sedimentation over the extent of the disturbance plume as a result of the construction of the new piers (piling) and capital dredging works	Low	N/A	Low	Medium
	Increased SSC and potential sedimentation as a result of the deposit of capital dredge material at a licensed offshore disposal site	Low	N/A	Low	Medium
	Changes in seabed bathymetry and composition as a result of deposition of dredged/disposal material within the area of the respective plumes	Low	N/A	Low	Medium
	Construction vessel activity – impacts on local hydrodynamics and sediment transport arising from ship wash and vessel propulsion	Low/negligible	N/A	Low/negligible	Medium
Operational Phase					
Physical processes	Local changes to hydrodynamic regime (flow speed and direction) as a result of the piers (piling) and capital dredging	Low	N/A	Low	Medium
	Local changes to the wave regime, as a result of the piers (piling) and capital dredging	Low	N/A	Low	Medium

Receptor	Impact Pathway	Exposure to change	Mitigation Measure	Residual Effect	Confidence
	Associated local changes to the sediment transport pathways, as a result of localised changes to the driving hydrodynamic (and wave) forcing	Low	N/A	Low	Medium
	Potential impact on existing features, including marine infrastructure, outfalls and estuary banks and channels	Hydrodynamics: Low Sediment transport: Low	 N/A N/A	 Low Low	 Medium Medium
	Increased SSC and potential sedimentation in the area of dispersal plume as a result of maintenance dredging	Low	N/A	Low	Medium
	Increased SSC and potential sedimentation as a result of deposition of maintenance dredge material at a licensed disposal site	Low	N/A	Low	Medium
	Changes in seabed bathymetry and composition as a result of deposition of dredged/disposed maintenance dredge material	Low	N/A	Low	Medium

16.11 References

Ref 16-1 European Commission (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Ref 16-2 The Stationery Office Limited (2009). Marine and Coastal Access Act 2009.

Ref 16-3 The Stationery Office Limited (2008). Planning Act 2008.

Ref 16-4 The Stationery Office (2017a). Statutory Instrument 2017 No. 407. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

Ref 16-5 The Stationery Office (2017b). Statutory Instrument 2017. No. 1012. The Conservation of Habitats and Species Regulations 2017.

Ref 16-6 The Stationery Office Limited (2019) The Floods and Water (Amendment etc.) (EU Exit) Regulations.

Ref 16-7 The Stationery Office Limited (2019). Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019.

Ref 16-8 The Stationery Office Limited (2011). Statutory Instrument 2011. No. 988. The Waste (England and Wales) Regulations 2011.

Ref 16-9 Department for Transport (2012). The National Planning Policy Statement for Ports. HMSO, London.

Ref 16-10 The Stationery Office Limited (2011). UK Marine Policy Statement.

Ref 16-11 Department for Environment, Food and Rural Affairs (Defra) (2019). UK Marine Strategy.

Ref 16-12 HM Government (2014). East Inshore and East Offshore Marine Plans.

Ref 16-13 Environment Agency (2010). SMP3: Flamborough Head to Gibraltar Point Shoreline Management Plan.

Ref 16-14 North East Lincolnshire Council (2018). North East Lincolnshire Local Plan.

Ref 16-15 Planning Inspectorate (2017). Advice Note Eighteen: The Water Framework Directive. Available at: https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-18/ (accessed November 2022).

Ref 16-16 UK Hydrographic Office (2022) Admiralty Tide Tables.

Ref 16-17 Environment Agency. (2018). Coastal flood boundary conditions for the UK: update 2018. Technical summary report. SC060064/TR6

Ref 16-18 British Geological Society (BGS) (2022). Geology Viewer. Available at: https://geologyviewer.bgs.ac.uk/?_ga=2.61621935.2025046977.1668593830-1031070941.1668593830 (accessed 16 November 2022).

Ref 16-19 ABPmer. (2004). Humber SMP2: Additional verification of morphological modelling, ABPmer Report No. R.1138. A report produced by ABPmer for Black & Veatch (on behalf of the Environment Agency), September 2004.

Ref 16-20 Folk, R.L. (1954). The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature. Journal of Geology, 62, 344-359.

Ref 16-21 Palmer, M., Howard, T., Tinker, J., Lowe, J., Bricheno, L., Calvert, D., Edwards, T., Gregory, J., Harris, G., Krijnen, J., Pickering, M., Roberts C., Wolf J. (2018). UK Climate Projections Science Report: UKCP18 Marine report. Met Office Hadley Centre: Exeter.

16.12 Abbreviations and Glossary of Terms

Table 16.10: Glossary and Abbreviations

Term	Acronym	Meaning
Appropriate Assessment	AA	The assessment of the impact on the integrity of a European site of a project or plan, either alone or in combination with other projects or plans, with respect to the site's structure and function and its conservation objectives.
Associated British Ports	ABP	One of the UK's leading and best connected ports groups, owing and operating 21 ports across England, Wales and Scotland.
Acoustic Wave and Current	AWAC	The Acoustic Wave and Current profiler performs measurement of wave height, wave direction and the full current profile.
Best Practical Environmental Option	BPEO	The Best Practicable Environmental Option is the idea that there is a unique, supremely beneficial method of disposing waste in a cost effective manner, in both the short and long term.
Below Seabed	BSB	-
Chart Datum	CD	A chart datum is the water level surface serving as origin of depths displayed on a nautical chart.
Candidate Special Area of Conservation	cSAC	A site proposed for designation under EU legislation for the protection of habitats and species considered to be of European interest.
Conductivity-Temperature Depth	CTD	A CTD is an instrument cluster that measures conductivity, temperature and depth.
Department for Environment, Food and Rural Affairs	Defra	The Government department responsible for policy and regulations on environmental, food and rural issues. The department's priorities are to grow the rural economy, improve the environment and safeguard animal and plant health.
Department for Transport	DfT	The Department for Transport is the United Kingdom government department responsible for the English transport network.
Exclusive Economic Zone	EEZ	An area of coastal water and seabed within a certain distance from a country's coastline, to which the country claims exclusive rights for fishing drilling and other economic activities.

Term	Acronym	Meaning
Environmental Impact Assessment	EIA	The statutory process through which the likely significant effects of a development project on the environment are identified and assessed.
Environmental Statement	ES	A statutory document which reports the EIA process, produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
European Union	EU	An economic and political union of 28 countries which operates an internal (or single) market which allows the free movement of goods, capital, services and people between member states.
Ground Investigation	GI	An intrusive investigation undertaken to collect information relating to the ground conditions, normally for geotechnical or land contamination purposes.
Highest Astronomical Tide	HAT	The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch.
Humber International Terminal	HIT	A terminal located within the Port of Immingham.
Habitats Regulations Assessment	HRA	An assessment of projects (or plans) potentially affecting European Sites in the UK, required under the Habitats Directive and Regulations. Also known as an assessment of implications on European Sites.
Significant Wave Height	Hs	The average wave height, from trough to crest, of the highest one-third of the waves.
Humber Sea Terminal	HST	-
Institute of Environmental Management and Assessment	IEMA	A professional body for practitioners working in the fields of environmental management and assessmen
Immingham Oil Terminal	IOT	An oil terminal operating out of the Port of Immingham.
Lowest Astronomical Tide	LAT	The lowest tide level that can be expected to occur under average meteorological conditions and any combination of astronomical conditions
Light Detection and Ranging	LiDAR	An airborne mapping technique which accurately measures the height of the terrain and surface objects on the ground, through the use of a scanning laser that measures the distance between the aircraft and the ground.

Term	Acronym	Meaning
Likely Significant Effect	LSE	A significant effect should be considered likely if it cannot be excluded on the basis of objective information and it might undermine a site's conservation objectives.
Marine and Coastal Access Act 2009	MCAA	The Act introduces a new system of marine management. This includes a new marine planning system, which makes provision for a statement of the Government's general policies, and the general policies of each of the devolved administrations, for the marine environment, and also for marine plans which will set out in more detail what is to happen in the different parts of the areas to which they relate.
Mean High Water Neaps	MHWN	The average throughout a year of the heights of two successive high waters during those periods of 24 hours when the range of the tide is least.
Mean High Water Springs	MHWS	The height of Mean Water High Springs is the average throughout the year, of two successive high waters, during a 24-hour period in each month when the range of the tide is at its greatest.
Marine Management Organisation	MMO	The Marine Management Organisation is an executive non-departmental public body in the United Kingdom established under the Marine and Coastal Access Act 2009, with responsibility for English waters.
Mean Sea Level	MSL	The average height of the sea over a longer time period.
National Policy Statement for Ports	NPSfP	A National Policy Statement (NPS) providing the framework for decisions on proposals for new port development.
Ordnance Datum Newlyn	ODN	See Ordnance Datum –Ordnance Datum Newlyn is located at the Newlyn Tidal Observatory.
Preliminary Environmental Information Report	PEI Report	A report that compiles and presents the Preliminary Environmental Information gathered for a project.
Planning Inspectorate	PINS	An executive agency with responsibilities for planning appeals, national infrastructure planning applications, local plan examinations and other planning-related casework in England and Wales.
Particle Size Analysis	PSA	Particle size analysis is used to characterise the size distribution of particles in a given sample.
Particle Size Distribution	PSD	The Particle Size Distribution of a powder, granulate, suspension or emulsion indicates the frequency of particles of a certain size in a sample.

Term	Acronym	Meaning
Potential Special Protection Area	pSPA	A sites proposed for designation under the European Directive on the Conservation of Wild Birds for the protection of birds in member states.
Representative Concentration Pathway	RCP	A greenhouse gas concentration (not emissions) trajectory adopted by the IPCC for its fifth Assessment Report in 2014
Special Area of Conservation	SAC	Sites designated under EU legislation for the protection of habitats and species considered to be of European interest.
Sunk Dredged Channel	SDC	The sunk dredged channel is the deep water channel through the outer Humber that allows access to the ports.
Sea Level Rise	SLR	Sea Level Rise is the increase in level of the world's oceans due primarily because of the effects of global warming.
Special Protection Area	SPA	Sites designated under the European Directive on the Conservation of Wild Birds for the protection of birds in member states.
Suspended Sediment Concentrations	SSC	Suspended sediment concentration is the total value of both mineral and organic material carried in suspension by a river.
Peak Wave Period	Tp	The wave period associated with the most energetic waves in the total wave spectrum at a specific point.
United Kingdom	UK	-
Water Framework Directive	WFD	A European Union Directive which commits member states to achieve good status of all waterbodies (both surface and groundwater), and also requires that no such waterbodies experience deterioration in status. Good status is a function of good ecological and good chemical status, defined by a number of elements.
Waste Hierarchy Assessment	WHA	If required, this assessment will involve an evaluation of the dredge and disposal methods likely to be involved and will follow the waste hierarchy of Prevention, Preparing for re-use à Recycling, Other Recovery, Disposal.
Wind Speed	WS	-